SEMIANNUAL STATUS REPORT

Theoretical and Experimental Studies of Antennas
for Reflectometer Application
1 December 1966 - 31 May 1967

The Ohio State University

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SEMIANNUAL STATUS REPORT 2143-3
9 June 1967

Grant Number NGR-36-008-048

National Aeronautics and Space Administration
Office of Grants and Research Contracts
Washington, D.C. 20546

N67-84798

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REPORT

by

The Ohio State University ElectroScience Laboratory
(Formerly The Antenna Laboratory)
Columbus, Ohio 43212

Sponsor	National Aeronautics and Space Administration Washington, D.C. 20546
Grant No.	NGR-36-008-048
Investigation of	Theoretical and Experimental Studies of Antennas for Reflectometer Application
Subject of Report	Semiannual Status Report (Theoretical and Experimental Studies of Antennas for Reflectometer Application)
Submitted by	ElectroScience Laboratory Department of Electrical Engineering
Date	9 June 1967

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SEMIANNUAL STATUS REPORT
(Theoretical and Experimental Studies of Antennas for Reflectometer Application)

I. INTRODUCTION

Research in the period 1 December 1966 through 31 May 1967 has been in the following three areas, each of which is discussed in some detail in Section II:

1. Reflection coefficient of a TEM waveguide in the presence of a metallic plate.

2. Aperture admittance of a circular aperture in a ground plane radiating into a homogeneous dielectric slab.

3. Experimental investigation of techniques for achieving monotone reflection magnitude from a ground plane antenna as a function of the distance d of a perfectly reflecting plane surface from the antenna.

II. WORK ACCOMPLISHED

1. The reflection coefficient of a TEM guide radiating into a conducting plate has been treated for several cases in which the guide walls are formed from conducting wedges. The ground plane case (90° wedge angles) and the case for which the wedge angles are small have been treated previously and are reported in Reference 1. The case for which the wedge angles are large (between 70° and 90°) are analyzed in the same basic manner as used in Reference 1. The analysis and computations are more laborious for this case because each reflection between the wedges and the conducting plate results in four cylindrical wave components rather than the two which result in the ground plane case. Computed results have been obtained using this analysis and a report is being written.

2. The admittance of a circular waveguide aperture in a ground plane covered by a homogeneous plane slab medium has been formulated using a variational method of analysis. The method is basically the same as that used by Compton,[2] and differs in the aperture geometry and field distribution used and in the fact that surface wave poles are taken into account.[3] In this approach, the fields in and beyond

the aperture are expressed as a Fourier integral over the plane wave spectrum of the aperture. The electric field in the aperture is assumed to have unit magnitude and to be of the dominant mode form for the aperture. Assumption of the electric field in the aperture allows inversion of the Fourier integral expression to find the spectrum of the fields. From this spectrum, the magnetic field in the aperture can be calculated. The admittance is then calculated as an integral of the cross product of the electric and magnetic fields over the aperture.

The integral for the TE_{11} mode admittance of the slab-covered circular waveguide has been programmed on the IBM 7094 computer and is being used to generate admittance data for the case of the lossless slab.

3. In order to accurately determine the distance $\underline{d}$ of a perfectly reflecting surface from an antenna in a ground plane, it is desirable to have the reflection magnitude in the antenna feed system be a monotone function of $\underline{d}$.

In the period from 31 May 1966 to 30 November 1966, experiments were performed which showed that addition of flaps to the E-plane walls of a pyramidal horn could result in a monotone reflection coefficient magnitude over a relatively large range of values of $\underline{d}$ for the case in which the horn was not mounted in a ground plane. Investigation (in the six month period just past) on similar horns mounted in a ground plane indicate that a monotone reflection magnitude versus distance curve will be more difficult to achieve for this case than for the case without ground plane.

III. FUTURE PROGRAM

The computer program for the circular aperture radiating into a slab will be extended to lossy media and aperture impedance and reflection coefficient data will be calculated for circular apertures and plasma media of interest. Of particular interest will be calculations which will show the relationship of the time-varying reflection magnitude as a function of the time-varying plasma electron densities. At least in the initial consideration of the time-varying problem, all plasma variations will be assumed slow as compared with the period of the microwave frequency used.

Techniques which are simpler and which will provide more insight than those used until now are needed for analysis of the aperture

admittance problem. One approach, which may provide both simplification and insight, is the Green's function type of analysis in which the magnetic fields in an aperture attributable to a delta-function electric field would be calculated for a given medium external to the aperture. The results would then be used to find the magnetic fields over an arbitrary aperture (given the E-fields) and these in turn would be used to calculate the aperture admittance as done previously. Analysis of aperture admittance using this Green's function technique will be begun and will be applied to the circular aperture.

One source of error in the variational method lies in the assumption of the form of the aperture electric-field. Numerical boundary-matching techniques will be applied to the circular aperture in order to provide a good estimate of the validity of the TE_{11} mode configuration for the electric field in the aperture.

The ultimate goal will be to combine the accurate knowledge of the aperture fields with the more general Green's function analysis to obtain more accurate calculations of aperture admittance in the presence of models of plasma media.

Research will be continued on the design of reflectometer antennas with a monotone reflection property. The use of small flaps attached to the aperture is one of the most promising approaches. In order to optimize the design of flaps for the case of the reflectometer antenna mounted in a ground plane, measurements will be made to determine the reflection of the flaps isolated from the ground plane structure. The reflection from the isolated flaps will also be analyzed so that the flaps can be systematically designed to minimize oscillations in the reflections from a reflecting plasma sheath.

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